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REVISED SITE INDEX CURVES FOR BALSAM FIR AND WHITE SPRUCE IN THE LAKE STATES

Willard H. Carmean, *Associate Professor,*
Lakehead University,
Thunder Bay, Ontario, Canada,
(formerly, Principal Soil Scientist,
North Central Experiment Station,
St. Paul, Minnesota),
and **Jerold T. Hahn,** *Principal Mensurationist,*
North Central Forest Experiment Station,
St. Paul, Minnesota

ABSTRACT.—The original site index curves for balsam fir and white spruce are revised from a breast height age to a total age basis. Site index values from these revised curves are thus comparable to site index values for other species that are based upon total tree age. This note also includes formulations for estimating site index by using computers or programmable, hand-held calculators.

KEY WORDS: total age revisions; site index formulation.

Harmonized site index curves have been published for balsam fir (*Abies balsamea* (L.) Mill.) and white spruce (*Picea glauca* (Moench) Voss) in the Lake States (Gevorkiantz 1956, 1957). These curves define site index as the height of dominant and codominant trees at breast-height-index age of 50 years. In contrast, the index age for most standard site index curves is total tree age at 50 years. Basing site index on breast height age avoids including much of the erratic initial height growth of trees that may suffer from early suppression, frost damage, or animal and insect injury. However, site index values estimated from curves based on breast height age cannot be directly compared to those estimated from site curves based on total tree age.

Our site index curves (figs. 1 and 2) for balsam fir and white spruce are adopted from the original Gevorkiantz harmonized site index curves. We have merely redrafted the original curves by converting them from breast height age to total tree age. Therefore, the revised site index curves have the shortcomings of the original harmonized curves.

These revised curves can be used in the field for directly estimating site index. But this process is slow and tedious, particularly when site indices are estimated from many trees such as in forest surveys or in timber management plans. Moreover, such site index estimates may be subject to error when interpolations are made between the site curves on the site index graphs. Therefore, we include height growth and site index equations that can be used with programmable, hand-held calculators or with programs written for digital computers.

METHODS

Unfortunately, the amount and kind of data and the statistical procedures used for the original curves are not well described by Gevorkiantz (1956, 1957). Data were probably total height and age values measured from dominant and codominant trees on forest survey and yield plots. These height and age data probably were then used for calculating average height-age guiding curves from which a family of proportional harmonized site index curves were constructed.

Using each of Gevorkiantz's site index curves, we read total tree height values for each 10-year breast height age. Then we added a number of years to breast height age to obtain total tree age, the number depending on site class:[1]

Site Index Class	30	40	50	60	70	80
Years added	15	13	11	10	9	8

The total age and total height values for each site class were then used to plot height-age curves. Proportional methods were used to adjust these plotted curves so that at a total age of 50 years the tree heights conformed exactly with the 50-year height specified for each site index class (figs. 1 and 2).

The values used for plotting the revised site index curves were next used for computing height growth equations that describe the revised curves. We also computed site index prediction equations. The equation models we used are:

$$H = b_1 S^{b_2(1-e^{b_3 A})^{b_4} S^{b_5}} \quad (1)$$

$$S = b_1 H^{b_2(1-e^{b_3 A})^{b_4} H^{b_5}} \quad (2)$$

where H = Total height of dominant and codominant trees in feet
S = Site index (total height of dominant and codominant trees at 50 years total age)
A = Total age in years
e = Base of the natural logarithms
b_1 .. b_5 = Parameters to be estimated, using weighted nonlinear least squares regression.

Parameters for balsam fir and white spruce are:

Species	b_1	b_2	b_3	b_4	b_5	R^2	SE	Bias
								(Percent)
Balsam fir H =	2.0901	0.9296	–0.0280	2.8280	–0.1403	0.99	0.54	0.01
Balsam fir S =	0.2198	1.1644	–0.0110	–2.0364	–0.1775	0.99	1.10	–1.17
White spruce H =	10.8738	0.5529	–0.0343	34.6880	–0.6139	0.99	2.33	–0.27
White spruce S =	0.0833	1.3965	–0.0196	–8.0895	–0.3659	0.98	3.22	2.11

[1]*These assumed years are currently used by the forest survey crews of the USDA Forest Service. Because the assuracy of these assumptions is unknown, much error in estimating both total age and site index can occur if trees initially grow faster or slower in height than assumed.*

DISCUSSION

Because these revised site index curves are based only on the original curves calculated by Gevorkiantz, they have the same errors and disadvantages of the original harmonized site index curves. New site curves based on stem analysis methods are recommended for balsam fir and white spruce in the Lake States.

When height growth and site index equations are used with a programmable calculator, the parameters and a simple program for solving the equation are entered and then stored. The estimates of site index are obtained by manually entering the species code and values for total height and total age.

The standard precautions in using site index curves also apply in using these equations for site index: site trees should be at least 20 years old and should be free growing, uninjured, dominant and codominant trees. Such trees commonly occur in well stocked, even-aged stands that have not been disturbed by past cutting. We recommend that increment cores for tree age be taken at breast height. Breast height age and total height values should then be compared to the site index curves for an estimate of the general site class. Next d.b.h. age should be converted to total age by using the number of years listed for each site class (figs. 1 and 2). These total age and total height values are then used for graphically estimating site index from the curves or for estimating site index using the formulae.

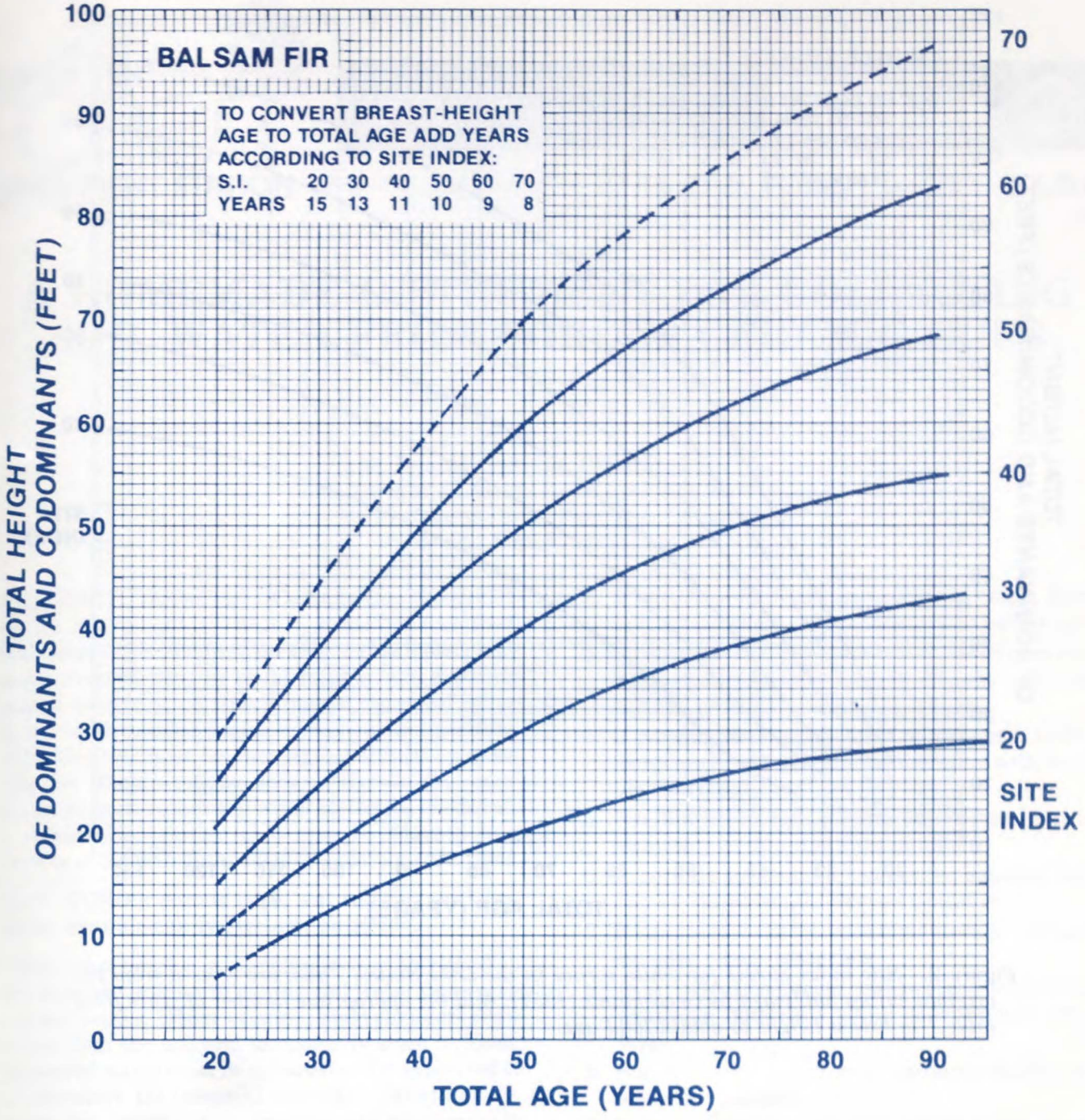
BALSAM FIR
TO CONVERT BREAST-HEIGHT AGE TO TOTAL AGE ADD YEARS ACCORDING TO SITE INDEX:
S.I. 20 30 40 50 60 70
YEARS 15 13 11 10 9 8
TOTAL HEIGHT OF DOMINANTS AND CODOMINANTS (FEET)
0 10 20 30 40 50 60 70 80 90 100
20 30 40 50 60 70 80 90
TOTAL AGE (YEARS)
20 30 40 50 60 70
SITE INDEX

Figure 1.—*Site index curves for balsam fir in the Lake States. These are revised from the original curves published by Gevorkiantz (1956). Add the appropriate number of years from table 1 to breast height age to obtain total age.*

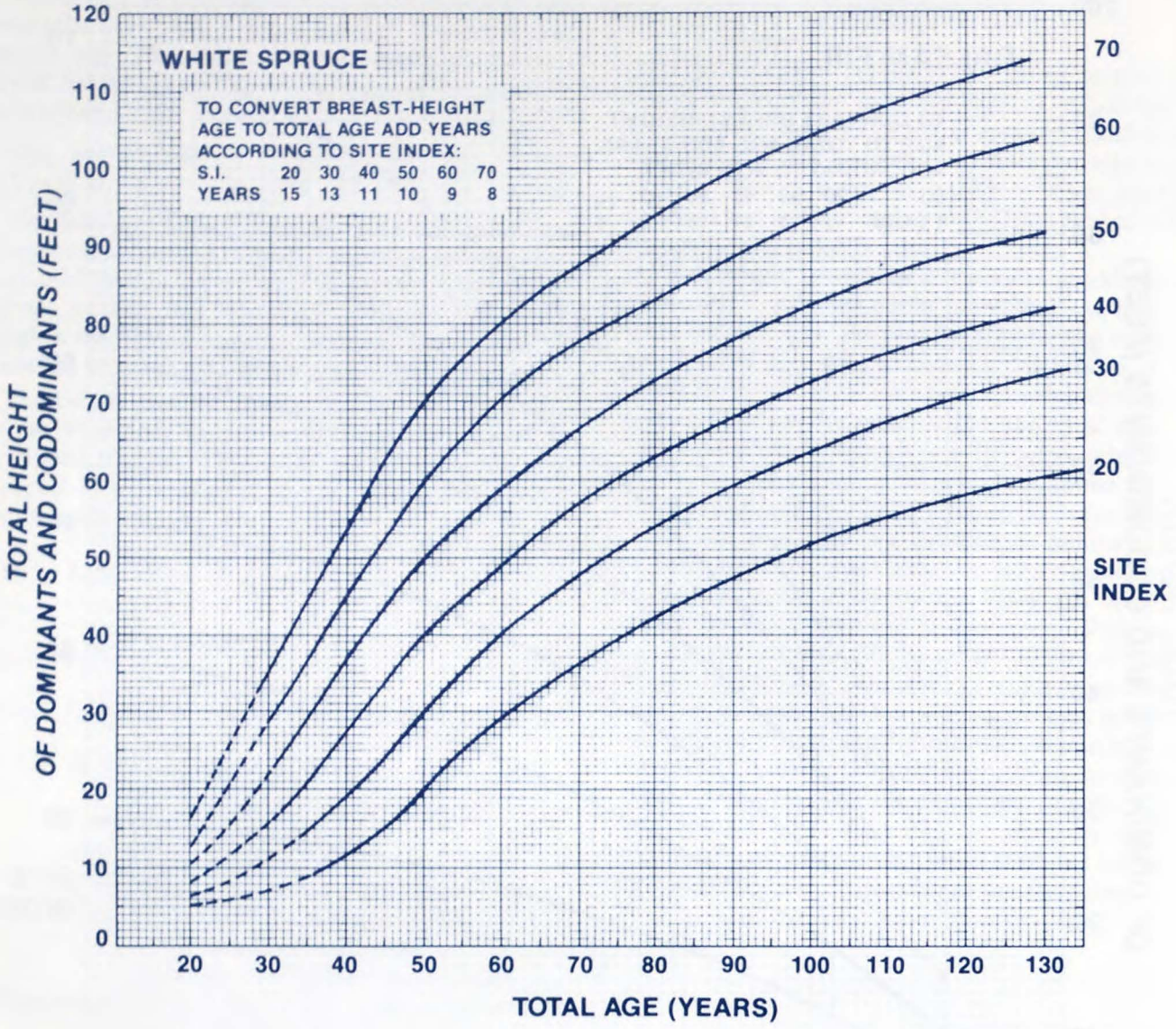
WHITE SPRUCE
TO CONVERT BREAST-HEIGHT AGE TO TOTAL AGE ADD YEARS ACCORDING TO SITE INDEX:
S.I. 20 30 40 50 60 70
YEARS 15 13 11 10 9 8
TOTAL HEIGHT OF DOMINANTS AND CODOMINANTS (FEET)
0 10 20 30 40 50 60 70 80 90 100 110 120
20 30 40 50 60 70 80 90 100 110 120 130
TOTAL AGE (YEARS)
70 60 50 40 30 20
SITE INDEX

Figure 2.—*Site index curves for white spruce in the Lake States. These are revised from the original curves published by Gevorkiantz (1957). Add the appropriate number of years from table 1 to breast height to obtain total age.*

LITERATURE CITED

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Gevorkiantz, S. R. 1957. Site index curves for white spruce in the Lake States. U.S. Department of Agriculture Forest Service, Technical Note 464, 2 p. U.S. Department of Agriculture Forest Service, Lake States Forest Experiment Station, St. Paul, Minnesota.

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